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Meta-analysis

Nurses' Knowledge on Ventilator-Associated Pneumonia: A Systematic Review and Meta-Analysis

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Abstract

Background: Mechanically ventilated patients are at risk of developing the iatrogenic infection ventilator-associated pneumonia (VAP). Inadequate knowledge of nurses is one of the obstacles to adherence to evidence-based guidelines to prevent VAP.
Objectives: This study aimed to estimate the knowledge of nurses about VAP prevention.
Methods: In this systematic review and meta-analysis, national and international databases, including MagIran, Scientific Information Database (SID), Web of Sciences, PubMed, and Scopus were searched using the following keywords: "Ventilator-associated pneumonia", "VAP", "Nosocomial pneumonia", "Knowledge", and their possible combinations. The VAP prevention score was calculated according to the questionnaire introduced and validated by Labeau et al. The analyses were performed using Stata (version 12).
Results: In the initial search, 1193 articles were found of which a total of 8 articles were included in the analysis. The nurses achieved 48.31% of the VAP prevention total score (Confidence Interval [CI]: 95%: 44.63-52). The lowest and highest VAP prevention scores were attributed to frequency of humidifier changes (15.13%, CI: 95%: 11.35-18.92) and patient positioning (81.03%, CI: 95%: 75.43-86.64), respectively. The percentage of nurses' knowledge about VAP prevention in Asian studies was higher than that in the European studies (54.71% versus 44.92%).
Conclusion: The nurses obtained less than half of the VAP prevention total score. Regular training courses and reviewing VAP prevention guidelines can keep nurses' knowledge up to date.

Keywords: Ventilator-associated pneumonia, Nurse, Meta-analysis.

Introduction

Ventilator-associated pneumonia (VAP) are the most prevalent nosocomial infections that are not present at the time of admission and develop 48 hours after endotracheal intubation or mechanical ventilation.[1] The mortality rate in the VAP patients ranges from 20% to 50%, and may increase to more than 70% when multi-resistant and invasive pathogens are the causes of the infection.[2] VAP increases the duration of hospitalization and treatment costs.[3,4]

In the US, the annual cost of VAP is about $2 billion, and every new case imposes $30,000 to $40,000 on the healthcare system.[5] Until now, different methods have been proposed for VAP prevention and management, such as avoiding unnecessary intubation, accurate aspiration of subglottic secretions, placing the patient's head at an angle above 30 degrees, physiotherapy, proper washing of hands, and use of the standard protocol for suctioning.[6] In 2004, Dodek et al., introduced the Evidence-Based Clinical Practice Guideline that included physical, positional, and pharmacological strategies that are useful for nurses.[7] VAP prevention is a still challenge for health care providers, especially nurses.[8]

Although awareness of the VAP prevention guidelines does not necessarily lead to adherence to them, inadequate knowledge about these guidelines can prevent their implementation.[9] Although numerous protocols have been proposed to prevent VAP or to reduce its prevalence, realizing this goal requires cooperation among different groups involved in treating this condition. However, the positive outcomes in this domain are mainly dependent on the quality of care provided by nurses.[10] Therefore, nurses' knowledge is the first step in implementing VAP prevention evidence-based guidelines.[9,11] Most physicians and nurses

learn about taking care of critically ill patients only through basic educational programs. They repeatedly encounter critically ill patients during training courses without adequate knowledge of providing evidence-based care.[12] Although VAP is not a new diagnosis, nurses can play an important role in preventing this infection by meeting the related guidelines. There are different instruments to assess nurses' knowledge regarding VAP. One of the popular instruments was developed by Labeau et al., which is a questionnaire consisting of 9multiple-choice questions with only one correct option for each question. The nurses' total score is calculated by summing the scores of the nine items. The item difficulty ranges from 0.1 to 0.9, and the item discrimination ranges from 0.10 to 0.65.[13] Previous studies have investigated the knowledge of nurses using this instrument and have reported various results.[6,9,11,14-18]

Objectives

Given that any training aimed at improving nurses' knowledge of VAP prevention requires adequate knowledge of the current situation, the goal of the present study was to estimate nurses' knowledge regarding VAP prevention.

Materials and Methods

Search strategy

In the present study, nurses' knowledge of VAP prevention was examined by analyzing Persian and English articles, published from 2007 to December 2019, based on the instrument developed by Labeau et al.,[13] Given that the Labeau et al.'s scale was developed in 2007, and the present study was based on this scale, we searched for articles published between 2007 and 2019.

In order to find the related articles, national databases, including Scientific Information Database (SID) and MagIran; and international databases, including Web of Science, PubMed, and Scopus were searched. The search was conducted using the following keywords: "Ventilator-associated pneumonia", "VAP", "Nosocomial pneumonia,", "Knowledge", and their possible combinations. The reference lists of the extracted articles were also reviewed to find other related studies. Because the national databases were not sensitive to Boolean Search Terms (NOT, AND, OR), they were searched using the following keywords: "Ventilator" and "Pneumonia." The search strategy in PubMed was as follows: Ventilator-associated [All Fields] AND (nosocomial [All Fields] AND ("pneumonia"[MeSH Terms] OR "pneumonia"[All Fields])) AND (VAP [All Fields] AND ("knowledge"[MeSH Terms] OR "knowledge"[All Fields]))

Study selection and data extraction

First, all the articles containing the above-mentioned keywords were collected, and then articles were selected based on the inclusion and exclusion criteria. The inclusion criteria were as follows: observational studies, use of the VAP prevention instrument developed by Labeau et al., and written in Persian or English. Some of the selected studies had used modified versions of the instrument and had added other items to it. The studies using the modified instruments were not included in the analysis. The score obtained from each study was reported as a percentage.

The search process and methodological examination were conducted by two independent researchers; any disagreement between them was resolved through discussion. The properties of the selected articles, including the name of the first author, year of publication, place of publication, sample size, and percentage of the total score on the items assessing nurses' knowledge of VAP prevention were recorded on an excel spreadsheet. Methodological quality was assessed based on the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE). This is a 22-item checklist assessing 6 different aspects of an article, including title, abstract, introduction, results, and funding.[19]

Statistical analysis

Because the selected articles had reported the nurses' knowledge of VAP prevention as percentages, the binomial distribution formula was used to assess this variable. The variance of each study was also assessed using the binomial distribution formula, and the percentage scores were pooled using the weighted mean, so that each study was assigned to a weight that was contrary to its variance. Due to the differences in the total and item scores between among studies and the significance of the heterogeneity indices, the random-effects model was used to combine the studies and estimate the percentage of the total and item scores. The I^2 index and the Cochran's Q test were used to examine heterogeneity between the selected studies. For the I^2 index, heterogeneity was divided into three classes: below 25% (low heterogeneity), in the range 25%-50% (moderate heterogeneity), and above 75% (high heterogeneity); and for the Cochran's Q test, $p<0.1$ indicated the significance of heterogeneity between the studies. The forest plot was used

to comprehensively show the selected studies based on effect sizes and confidence intervals (95%). A forest plot was also used to show the percentages of total and item scores of nurses reported in the selected studies and the 95% confidence intervals. The selected studies were divided by continent (Europe and Asia), and the percentages of nurses' scores on the VAP prevention items were reported by continent using the subgroup analysis.

The relationship of nurses' total knowledge of VAP prevention with articles' year of publication and sample size was examined using the univariate meta-regression. Finally, the sensitivity analysis was used to assess the role of each study in the final result, and the Funnel plots based on the Egger's regression tests were used to examine the effect of small studies and the potential publication error. All the analyses were performed using the Stata (version 12).

Results

In the present study, all the studies on nurses' knowledge of VAP prevention, published in Persian or English, were systemically reviewed and meta-analyzed, using the PRISMA statement. In the initial search, 1193 articles were identified, of which a total of 8 articles were included in the final analysis based on the inclusion and exclusion criteria (Figure-1).

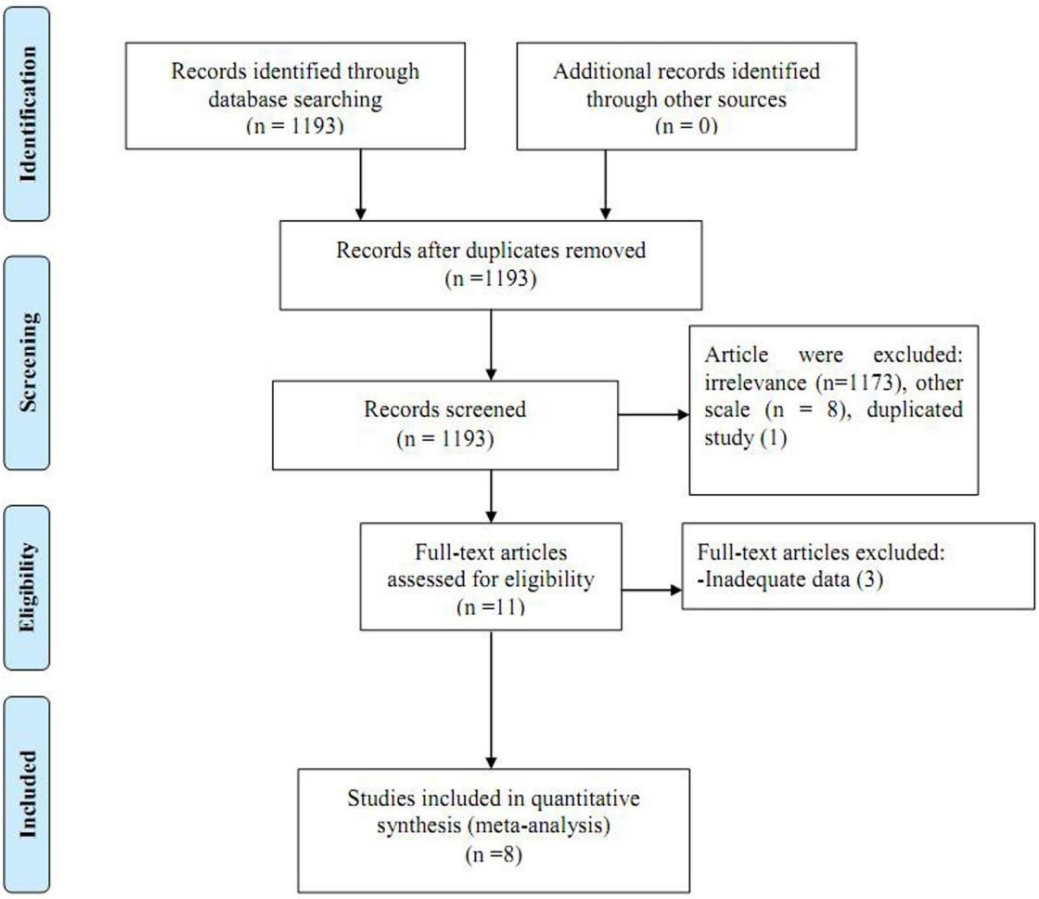

Figure-1. Screening flowchart showing the selection of qualified articles according to the PRISMA statement.

Finally, 8 qualified studies with a total sample size of 7818 (an average of 978 participants in each study) were included in the analysis. Among them, 5 studies were from Asia (Iran, Turkey, and Lebanon)[6,9,11,14,16] and 3 were from Europe.[13,15,18] All the studies had been conducted between 2007 and 2016. The highest and lowest total scores of VAP prevention were reported in the studies by El-Khatib et al., (79.89%) and Blot et al., (41.23%), respectively.[9,15] More details are provided in Table-1.

The analyses showed that the nurses obtained 48.31% (CI: 95%: 44.63-52) of the VAP prevention total score. Table-2 shows the nurses' VAP prevention in total scores.

Table-1. Characteristics of the selected studies.

First Author	Year	Sample size	Place	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Firouzian [16]	2016	120	Iran	81.7	53.3	42.5	6.7	62.5	38.3	30	46.7	85.8	49.72
Yeganeh [11]	2015	171	Iran	56.7	34.5	70.8	19.3	72.5	29.2	39.8	52.6	87.1	51.39
Bagheri-Nesami [14]	2014	52	Iran	34.6	17.3	78.8	3.8	80.8	13.5	65.4	90.4	82.7	51.92
Akın Korhan [6]	2013	138	Turkey	79	62.3	39.1	17.4	68.8	16.7	23.9	54.3	29.7	43.47
Llauradó [18]	2011	3329	6 European countries	63.8	43.7	37.2	18.2	46.6	22.3	44.9	59.9	83.8	46.71
El-Khatib [9]	2010	41	Lebanon	76	68	84	26	92	87	97	92	97	79.89
Labeau [17]	2008	3329	22 European countries	54.7	35.1	38.2	21.4	45.7	18.2	50.6	57.3	85.1	45.14
Blot [15]	2007	638	Belgium	18.7	48.6	54.7	13.3	16.9	19.6	60.3	48.7	90.3	41.23

Table-2. Nurse' scores on different items of VAP prevention by continent.

Domain	Subgroup	Number of studies	Proportion of scores (%)	Confidence Interval 95%	Heterogeneity		
					I^2 (%)	Q	P
Q1	Asia	5	66.04	51.11-80.97	93.3	59.63	<0.0001
	Europe	3	45.78	24.86-66.70	99.7	661.99	<0.0001
	Total	8	58.07	45.04-71.10	99.1	789.03	<0.0001
Q2	Asia	5	46.82	29.93-63.72	94.0	67.09	<0.0001
	Europe	3	42.31	34.99-49.63	97.2	72.50	<0.0001
	Total	8	44.52	38.29-50.75	95.2	145.54	<0.0001
Q3	Asia	5	62.82	45.13-80.51	94.9	78.50	<0.0001
	Europe	3	43.10	35.96-50.18	97.1	68.95	<0.0001
	Total	8	54.50	46.58-62.42	97.2	254.36	<0.0001
Q4	Asia	5	13.55	6.31-20.79	85.3	27.21	<0.0001
	Europe	3	17.79	14.04-21.56	93.5	30.80	<0.0001
	Total	8	15.13	11.35-18.92	92.2	89.89	<0.0001
Q5	Asia	5	75.2	65.40-85.01	85.8	28.19	<0.0001
	Europe	3	36.45	21.56-51.35	99.4	332.85	<0.0001
	Total	8	60.14	48.38-71.91	98.9	645.42	<0.0001
Q6	Asia	5	36.75	14.84-58.67	97.3	150.57	<0.0001
	Europe	3	20.10	17.08-23.04	88.5	17.46	<0.0001
	Total	8	28.91	22.90-34.92	96.6	204.31	<0.0001
Q7	Asia	5	51.21	18.89-83.53	98.9	372.14	<0.0001
	Europe	3	51.71	44.94-58.47	96.7	60.01	<0.0001
	Total	8	51.49	41.23-61.74	98.5	462.39	<0.0001
Q8	Asia	5	67.21	47.97-86.46	96.4	110.63	<0.0001
	Europe	3	55.70	51.10-60.30	92.8	27.60	<0.0001
	Total	8	62.28	55.91-68.64	95.7	162.73	<0.0001
Q9	Asia	5	76.54	55.39-97.69	98.2	217.83	<0.0001
	Europe	3	86.23	83.25-89.21	91.6	23.78	<0.0001
	Total	8	81.03	75.43-86.64	97.2	247.32	<0.0001

The results showed that the highest frequency of correct answers was on item 9 (81.03%, CI: 95%: 75.43-86.64) that assessed nurses' knowledge of the patient's position. In addition, the lowest frequency of correct answers was on item 4 (15.13%, CI: 95%: 11.35-18.92) that assessed the frequency of humidifier changes. The results also indicated that less than half of the nurses answered correctly to the items 2 (frequency of ventilator circuit changes), 4 (frequency of humidifier changes), and 6 (frequency of change in suction systems). Figure-3 presents nurses' scores on different items of VAP prevention.

Nurses' total knowledge of VAP prevention was higher in the Asian studies (54.71%, CI: 95%: 44.07-65.65) than that in the European studies (44.92%, CI: 95%: 42.58-47.27). The results by continent (Asia or Europe) indicated that the percentage of correct answers on the items Q4 and Q9 was

higher in the European than in that the Asian studies, the percentage of correct answers on the item Q7 were similar in the studies conducted in both continents, and on the remaining items, the percentage of correct answers was higher in the Asian than in the European studies. According to the meta-regression results, no significant relationship was found between nurses' VAP prevention total score and sample size (p=0.436) and year of publication (p=0.808).

The sensitivity analysis results showed that none of the studies had a significant effect on the estimation of nurses' total knowledge of VAP prevention. In addition, the publication error was not significant (p =0.250).

The meta-regression analysis showed no significant relationship between nurses' knowledge of VAP prevention and sample size (p=0.436) and year of publication (p=0.808).

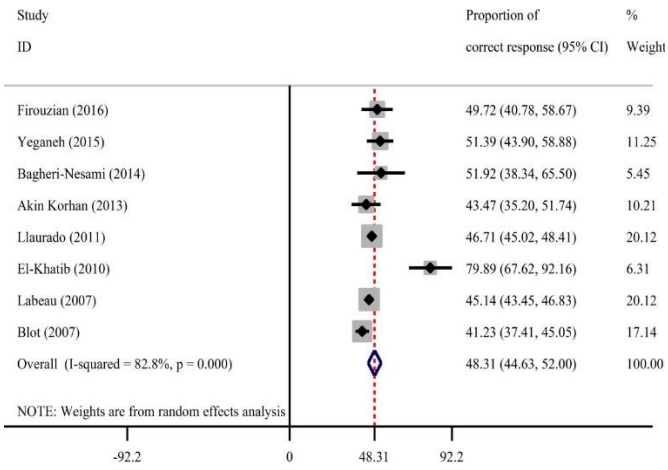

Figure-2. Forest plot of the percentages of nurses' total knowledge of VAP prevention

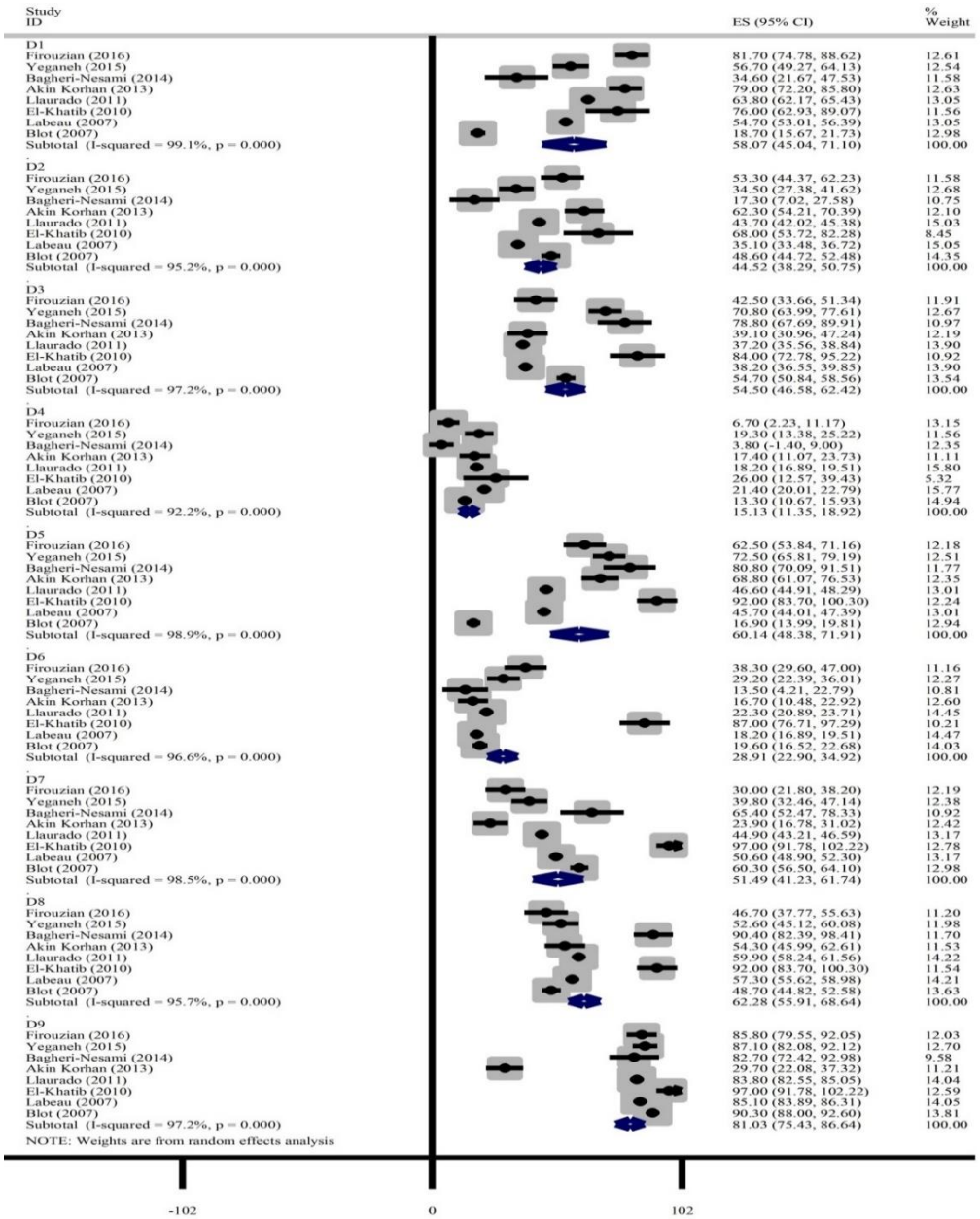

Figure-3. Forest plot of nurses' scores on different items of VAP prevention

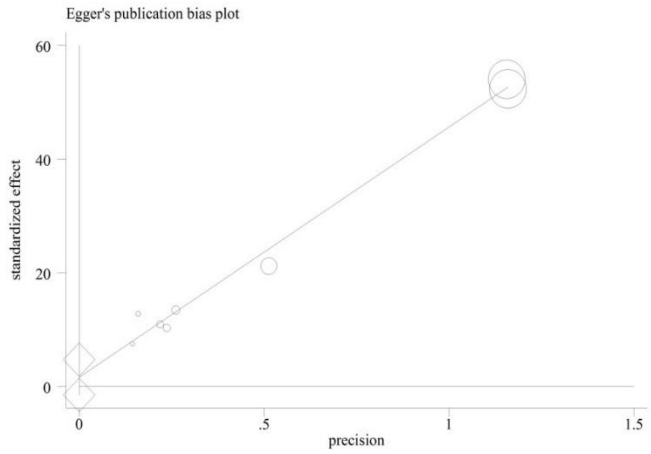

Figure-4. Publication bias

Discussion

In the present meta-analysis, a total of 8 studies with a total sample size of 7818 were analyzed to estimate nurses' knowledge of VAP prevention. The results demonstrated that the nurses obtained 48.31% (CI: 95%: 44.63-52) of the VAP prevention total score (less than half of the total score). In other words, the nurses' knowledge of VAP prevention was not adequate. Due to the important role of nurses in VAP prevention, and relationship of this problem with high proportion of nosocomial infections. This finding may indicate a gap between the actual nursing care and the educational content that they learn during training; this potentially reduces the quality of care provided for the patients and threatens their health. Due to the importance of VAP prevention on the reduction of nosocomial infections, a change in the nursing training processes or even in the hospitals' general policies may be necessary to reduce nosocomial infections.

The analyses showed that the most correct answers were on the Patient positioning item. This finding showed that the nurses had a good knowledge regarding the prevention of gastroesophageal reflux and bacteria aspiration in patients under mechanical ventilation by placing the patient's head at a 30 degrees angle or above. In a meta-analysis by Alexiou et al., aimed at examining the impact of patient position on the incidence of VAP, the risk of VAP in patients in a semi-sitting position with 45 degrees head elevation was significantly lower than in those with 15-30 degrees head elevation.[20] Nurses know that the supine position in every patient increases the risk of aspiration and finally pneumonia, through changing the level of consciousness (even if the patient t is not under mechanical ventilation). Drakulovic et al., found that patients in the supine position were at a higher risk of developing VAP compared to those in the semi-upright sitting position (Head-of-bed elevation of 45 degrees).[21]

Nasogastric intubation can impair the functioning of the upper esophageal sphincter, and increases the risk of reflux by increasing the risk of proliferation of microorganisms in the upper digestive system (mouth and stomach). This chain of factors can lead to the migration of bacteria into the lower airway, and therefore results in pneumonia. Finally, the increased risk of reflux and aspiration increases the risk of ventilator-associated pneumonia. Therefore, there is a high risk of VAP in patients under mechanical ventilation who are tube-fed.[22-25] Nurses' lowest scores were on the Frequency of humidifier changes item. In Labeau et al., study in Europe also about 21% of the nurses were aware of the proper times for changing humidifier filters.[17]

Although changing heat and moisture exchanger (HME) filters has been recommended as a useful activity in VAP prevention,[7] Menegueti et al., in a meta-analysis on the examination of the effectiveness of changing HME filters in VAP prevention, reported that the HME was not effective.[26] There is not still a consensus on the most useful type of humidifier. Some studies have reported no significant difference in the incidence of VAP between the two systems.[27,28] Kirton et al., showed the effectiveness of HMES in reducing the incidence of VAP, while, Cohen found that the use of HHS reduced the incidence of VAP.[29] In a clinical trial, Lorene et al., compared the incidence of VAP using heated humidifiers (HH) or heat and moisture exchangers (HME). The results indicated that there was a lower incidence of VAP with HH than with HME.[30] The study results showed that less than half of the nurses answered correctly to the items assessing the frequency of changing ventilator circuits, humidifiers, and suction systems. It seems that changing these items is more dependent on the hospital's policies and nurses may not have enough power to change these policies. In addition, considering that each particular hospital may have its own policies, and hence the nurses may not be able to change these items.

In a meta-analysis that was conducted by Han and Lui, the patients who received circuit changes every 2 days had a higher risk of developing VAP compared to those who received circuit changes every 7 days.[31] In addition to the aforementioned factors regarding nurses' awareness of the

proper times of humidifiers changes, it should be noted that changing these items is often guided by hospitals' policies and nurses may not be able to change these policies. In addition, because each hospital may have its own specific policies, nurses are not allowed to change the items. In a clinical trial, patients under mechanical ventilation were divided into two groups: in one group, the ventilator was changed every 7 days (ventilator circuit changes), and in the second group, it was not changed at all. The results showed that the incidence of VAP was not significantly different between the two groups of patients (28% versus 24%), but ventilator changes were costly for the patients.[32]

The difference between nurses' scores in the Asian and European studies can be attributed to different trainings or even differences in the nursing curriculums. Overall, the differences in the reported scores in the reviewed studies can be due to the healthcare models provided for the nurses, nurses' routine tasks, lack of access to national or international guidelines, or differences in health policies. Non-adherence to VAP prevention guidelines is not limited to a specific group of healthcare providers and is observed in all the groups involved. According to reports, the rate of non-adherence to VAP prevention guidelines is 37% for doctors and 22% for nurses.[33,34]

The strength of the present study was that it was the first meta-analysis focused on nurses' knowledge of VAP prevention. In the meta-analysis studies, a more reliable estimation of the phenomenon is reported, because the results of different studies are combined, and a larger sample is used, without the need to spend additional money to increase the size of the sample or dedicating more time to have a larger study. Therefore, our findings presented the current status of nurses' knowledge of VAP prevention, based on the previous studies conducted on this subject and by taking a broader look at nurses' conditions, especially those in Asia and Europe.

One of the limitations of the present study was that nurses' knowledge of VAP prevention had been reported using different instruments, but we were not able to analyze the findings based on all the instruments used.

Conclusions

Overall, the results indicated that the nurses obtained less than half of the VAP prevention total score. Therefore, it seems necessary to provide training and workshops for nurses to improve their knowledge of VAP prevention in terms of the proper time of changing ventilator circuits, humidifiers, and suction systems.

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Authors' Contribution

All authors pass the four criteria for authorship contribution based on the International Committee of Medical Journal Editors (ICMJE) recommendations.

Conflict of Interests

The authors declared no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

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References

1. Zubair S, Ali H, Zafar F, Raza SF, Ashraf I, Warind J, et al. Ventilator-associated pneumonia. The Professional Medical Journal. 2018;25(09):1356-63. doi:10.29309/TPMJ/18.4482
2. Rea-Neto A, Youssef NCM, Tuche F, Brunkhorst F, Ranieri VM, Reinhart K, et al. Diagnosis of ventilator-associated pneumonia: a systematic review of the literature. Critical Care. 2008;12(2):56. doi:10.1186/cc6877
3. Safdar N, Dezfulian C, Collard HR, Saint S. Clinical and economic consequences of ventilator-associated pneumonia: a systematic review. Critical Care Medicine. 2005;33(10):2184-93. doi:10.1097/01.CCM.0000181731.53912.D9
4. Warren DK, Shukla SJ, Olsen MA, Kollef MH, Hollenbeak CS, Cox MJ, et al. Outcome and attributable cost of ventilator-associated pneumonia among intensive care unit patients in a suburban medical center. Critical Care Medicine. 2003;31(5):1312-7. doi:10.1097/01.CCM.0000063087.93157.06
5. Hillier B, Wilson C, Chamberlain D, King L. Preventing ventilator-associated pneumonia through oral care, product selection, and application method: a literature review. AACN Advanced Critical Care. 2013;24(1):38-58. doi:10.1097/NCI.0b013e31827df8ad
6. Akın Korhan E, Hakverdioğlu Yunt G, Parlar Kılıs S, Uzelli D. Knowledge levels of intensive care nurses on prevention of ventilator-associated pneumonia. Nursing in Critical Care. 2014;19(1):26-33. doi:10.1111/nicc.12038
7. Dodek P, Keenan S, Cook D, Heyland D, Jacka M, Hand L, et al. Evidence-based clinical practice guideline for the prevention of ventilator-associated pneumonia. Annals of Internal Medicine. 2004;141(4):305-13. doi:10.7326/0003-4819-141-4-200408170-00011
8. Ruffell A, Adamcova L. Ventilator-associated pneumonia: prevention is better than cure. Nursing in Critical Care. 2008;13(1):44-53. doi:10.1111/j.1478-5153.2007.00248.x

9. El-Khatib MF, Zeineldine S, Ayoub C, Husari A, Bou-Khalil PK. Critical care clinicians' knowledge of evidence-based guidelines for preventing ventilator-associated pneumonia. American Journal of Critical Care. 2010;19(3):272-6. doi:10.4037/ajcc2009131
10. Bird D, Zambuto A, O'Donnell C, Silva J, Korn C, Burke R, et al. Adherence to ventilator-associated pneumonia bundle and incidence of ventilator-associated pneumonia in the surgical intensive care unit. Archives of Surgery. 2010;145(5):465-70. doi:10.1001/archsurg.2010.69
11. Yeganeh M, Yekta H, Farmanbar R, Khalili M, Atrkar roushan Z. Knowledge of evidence-based guidelines in Ventilator-Associated Pneumonia prevention. Journal of Evidence-Based Medicine. 2016. doi:10.1111/jebm.12188
12. Usman HS, Atif I, Rashid F, Zulfiqar H, Mian K, Sarfraz M, et al. Knowledge and practices of critical care health professionals related to ventilator associated pneumonia in tertiary care hospitals of Islamabad and Rawalpindi. The Journal of the Pakistan Medical Association. 2017;67(11):1714-8.
13. Labeau S, Vandijck D, Claes B, Van Aken P, Blot S. Critical care nurses' knowledge of evidence-based guidelines for preventing ventilator-associated pneumonia: an evaluation questionnaire. American Journal of Critical Care. 2007;16(4):371-7. doi:10.4037/ajcc2007.16.4.371
14. Bagheri-Nesami M, Amiri M. Nurses' knowledge of evidence-based guidelines for preventing ventilator-associated pneumonia in intensive care units. Journal of Nursing and Midwifery Sciences. 2014;1(1):44-8. doi:10.4103/2345-5756.231389
15. Blot SI, Labeau S, Vandijck D, Van Aken P, Claes B. Evidence-based guidelines for the prevention of ventilator-associated pneumonia: results of a knowledge test among intensive care nurses. Intensive care medicine. 2007;33(8):1463-7. doi:10.1007/s00134-007-0705-0
16. Firouzian A, Baradari AG, Fazli M, Askari S, Kerdabadi EH, General Practitioner YR, et al. Knowledge of Intensive Care Unit Nurses about Non-Pharmacological Prevention of Ventilator-Associated Pneumonia. Journal of Mazandaran University of Medical Sciences. 2016;26(141): 170-4
17. Labeau S, Vandijck D, Rello J, Adam S, Rosa A, Wenisch C, et al. Evidence-based guidelines for the prevention of ventilator-associated pneumonia: results of a knowledge test among European intensive care nurses. Journal of Hospital Infection. 2008;70(2):180-5. doi:10.1016/j.jhin.2008.06.027
18. Llaurady M, Labeau S, Vandijck D, Rello J, Rosa A, Riera A, et al. Southern European intensive care nurses' knowledge of evidence-based guidelines for preventing ventilator-associated pneumonia. Medicina Intensiva (English Edition). 2011;35(1):6-12. doi:10.1016/S2173-5727(11)70003-0
19. Farrugia M, Kirsch A. Application of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement to publications on endoscopic treatment for vesicoureteral reflux. Journal of Pediatric Urology. 2017;13(3):320-5. doi:10.1016/j.jpurol.2017.02.005
20. Alexiou VG, Ierodiakonou V, Dimopoulos G, Falagas ME. Impact of patient position on the incidence of ventilator-associated pneumonia: a meta-analysis of randomized controlled trials. Journal of Critical Care. 2009;24(4):515-22. doi:10.1016/j.jcrc.2008.09.003
21. Drakulovic MB, Torres A, Bauer TT, Nicolas JM, Noguй S, Ferrer M. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: a randomised trial. The Lancet. 1999;354(9193):1851-8. doi:10.1016/S0140-6736(98)12251-1
22. Alp E, Voss A. Ventilator associated pneumonia and infection control. Annals of Clinical Microbiology and Antimicrobials. 2006;5(1):7-11. doi:10.1186/1476-0711-5-7
23. Erbay RH, Yalcin AN, Zencir M, Serin S, Atalay H. Costs and risk factors for ventilator-associated pneumonia in a Turkish university hospital's intensive care unit: a case-control study. BMC Pulmonary Medicine. 2004;4(1):3-10. doi:10.1186/1471-2466-4-3
24. Kollef MH. Prevention of ventilator-associated pneumonia. Critical Care Infectious Diseases Textbook: Springer; 2001: 707-17. doi:10.1007/978-1-4615-1679-8_43
25. Sabery M, Shiri H, Taghadosi M, Gilasi HR, Khamechian M. The frequency and risk factors for early-onset ventilator-associated pneumonia in intensive care units of Kashan Shahid-Beheshti hospital during 2009-2010. KAUMS Journal (FEYZ). 2013;16(6):560-9.
26. Menegueti MG, Auxiliadora-Martins M, Nunes AA. Effectiveness of heat and moisture exchangers in preventing ventilator-associated pneumonia in critically ill patients: a meta-analysis. BMC Anesthesiology. 2014;14(1):115. doi:10.1186/1471-2253-14-115
27. Lacherade J-C, Auburtin M, Cerf C, Van de Louw A, Soufir L, Rebufat Y, et al. Impact of humidification systems on ventilator-associated pneumonia: a randomized multicenter trial. American Journal of Respiratory and Critical Care Medicine. 2005;172(10):1276-82. doi:10.1164/rccm.200408-1028OC
28. Memish ZA, Oni GA, Djazmati W, Cunningham G, Mah MW. A randomized clinical trial to compare the effects of a heat and moisture exchanger with a heated humidifying system on the occurrence rate of ventilator-associated pneumonia. American Journal of Infection Control. 2001;29(5):301-5. doi:10.1067/mic.2001.115404
29. Kirton OC, DeHaven B, Morgan J, Morejon O, Civetta J. A prospective, randomized comparison of an in-line heat moisture exchange filter and heated wire humidifiers: rates of ventilator-associated early-onset (community-acquired) or late-onset (hospital-acquired) pneumonia and incidence of endotracheal tube occlusion. Chest. 1997;112(4):1055-9. doi:10.1378/chest.112.4.1055
30. Lorente L, Lecuona M, Jimйnez A, Mora ML, Sierra A. Ventilator-associated pneumonia using a heated humidifier or a heat and moisture exchanger: a randomized controlled trial [ISRCTN88724583]. Critical Care. 2006;10(4):R116. doi:10.1186/cc5009
31. Han J, Liu Y. Effect of ventilator circuit changes on ventilator-associated pneumonia: a systematic review and meta-analysis. Respiratory Care. 2010;55(4):467-74.
32. Kollef MH, Shapiro SD, Fraser VJ, Silver P, Murphy DM, Trovillion E, et al. Mechanical ventilation with or without 7-day circuit changes: a randomized controlled trial. Annals of Internal Medicine. 1995;123(3):168-74. doi:10.7326/0003-4819-123-3-199508010-00002
33. Rello J, Lorente C, Bodн M, Diaz E, Ricart M, Kollef MH. Why do physicians not follow evidence-based guidelines for preventing ventilator-associated pneumonia?: a survey based on the opinions of an international panel of intensivists. Chest. 2002;122(2):656-61. doi:10.1378/chest.122.2.656
34. Ricart M, Lorente C, Diaz E, Kollef MH, Rello J. Nursing adherence with evidence-based guidelines for preventing ventilator-associated pneumonia. Critical Care Medicine. 2003;31(11):2693-6. doi:10.1097/01.CCM.0000094226.05094.AA